PROJECT facts

U.S. DEPARTMENT OF ENERGY
OFFICE OF FOSSIL ENERGY
NATIONAL ENERGY TECHNOLOGY LABORATORY

High Efficiency Engines and Turbines

12/2002

EXTENDING THE LEAN BLOWOUT LIMITS OF LOW NO_X GAS TURBINES BY CONTROL OF COMBUSTION INSTABILITIES

PRIMARY PROJECT PARTNER

Georgia Institute of Technology
Atlanta, GA 30332

TOTAL ESTIMATED COST

$ 510,329.

CUSTOMER SERVICE

800-553-7681

STRATEGIC CENTER FOR NATURAL GAS WEBSITE

www.netl.doe.gov/scng

Description

This Advanced Gas Turbine Systems Research (AGTSR) project builds on the success of an earlier AGTSR project that identified a promising active control approach for low NO_X turbine combustors. That control scheme periodically modulates a portion of fuel injected into the combustor to produce heat release oscillations out of phase with the combustor oscillation. The approach was successfully tested at a Siemens-Westinghouse combustor facility. The following figure shows pressure oscillations in a test combustor during operation without control, during an identification period when the oscillations are monitored to set control parameters, and after control has been initiated. The active control has produced a four-fold reduction in amplitudes of oscillations.

Two patents have been issued and a third is in process for this active control approach. GT has been transferring this technology to the US gas turbine industry. As a result of its success, GT is establishing working arrangements with several gas turbine manufacturers to test or evaluate adapting this control approach to turbine combustors. These companies include General Electric, Rolls-Royce, Siemens-Westinghouse, and United Technologies Research Center (Pratt&Whitney).

One of the three tasks of the current AGTSR program will further improve and produce a practical active control system based on the approach developed in the previous AGTSR program. Two additional tasks are investigating mechanisms and passive control by i) distributed fuel injection, ii) modification of fuel line properties to eliminate or reduce coupling between fuel line and combustor inlet oscillations, iii) pulsation of the pilot fuel injection rate at a fixed frequency, iv) addition of a tunable Helmholtz resonator at the inlet to increase acoustic damping, and v) use of a splitter pipe to produce periodic flow vortex structures that are out of phase.

Extending the Lean Blowout Limits of Low NO_X Gas Turbines by Control of Combustion Instabilities

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Duration

36 months

Project Goals

This program investigates both passive and active control of detrimental combustion instabilities in low NO_X turbines, which burn natural gas in a lean premixed mode to reduce emissions. Methods of passive control of instabilities are being explored because of simplicity of implementation. Active control of instabilities is being explored because adequate passive control may not be possible for all low emission turbines.

Project Benefits

Lean premixed low NO_X turbine combustors operate in a regime closer to lean blowout limits than conventional combustors. This results in combustion pressure oscillations and instabilities with accompanying noise and vibration. Such combustor noise has been unacceptable and vibration induced fatigue has caused structural failures in engines and removal of commercial turbines from service for repair. This project will develop control approaches to alleviate combustor oscillations, noise and damaging vibrations. These control approaches will also offer the potential for operation of low emission combustors closer to the lean blowout limits where additional reduction of NO_X emissions is possible.